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Hybrid Bamboo Space Grid Structure For Sustainable Envelope

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Abstract:

Bamboo is one of those providential developments in Nature which, like the horse, thecow, wheat and cotton, have been indirectly responsible for man's own evolution. It is a giant grass, inherently, a Nature grown pipe and is the fastest growing plant in the world. It is a big carbon sink, having multiple usages and zero waste material having more than 10,000 documented uses.
Space grid structures are a rigid, lightweight, truss-like, two-way spanning, single or double layer or triple layer structure, constructed from interlocking struts in a geometric pattern, in flat or curved plane. These are widely used for industrial buildings, factories, sports halls, warehouses, swimming pools, conference halls and exhibition centers, stadiums with long span etc.
Space grid structures are made up of struts and internodes. Conventionally steel is being used for both elements. If we replace steel struts with bamboo struts, it will make the structure, cost and time efficient with added goodness and elegance of bamboo. For this purpose, bamboo has all mechanical properties to withstand the structural tests and internodes are specifically designed for the purpose.
The paper talks about the structural properties of bamboo and how the internodes' design can change the utility and efficiency of Space grid structures and make them sustainable.
Concluding, it can be said that due to increase in calamities, the demand for temporary structures has gone up. In such circumstances Hybrid Bamboo Structures are efficient solution toprovide Sustainable Built Envelope.

Keywords: Bamboo, Space Grid Structures, Sustainable, Low Carbon emissions

Introduction:

Sustainable building envelope is one among the four primary global challenges that thehumanity is confronted with. For medium and large span building envelopes, space grid structures prove to be most efficient. Bamboo is a versatile engineering material. Hybrid bamboo space grid structures being made from renewable sources and with their relatively low embodied energy are preferred choice for small and medium span structures. Thus, making building envelopes sustainable.

Methodology:

1.0 Bamboo- a sustainable and versatile engineering material:

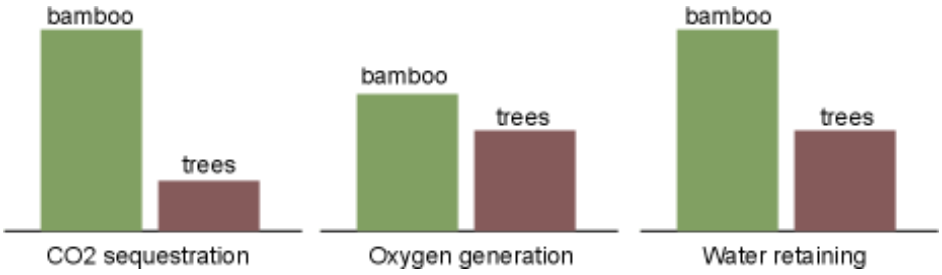
Bamboo, also known as a giant grass, is inherently, a Nature grown pipe and is the fastestgrowing plant in the world. A few species of bamboo grow as fast as 47.6 inches in a period of 24-hours. There are over a thousand species all over the planet that are native to every continent except Europe, North America and the poles. It sustains extremes of drought and drowning, generates more oxygen than trees and is considered a critical element in the balance between oxygen and carbon dioxide in the atmosphere.

1.01 Resilience of Bamboo

Resilience Means the property of a substance to return to its usual shape after being bent, stretched, or pressed, the amount of potential energy stored in an elastic material when deformed and the ability to recover strength, spirits, good humor, etc. quickly. This property helps farmers in extreme conditions like drought, floods, earth quakes etc. When all the crops will get spoiled due to natural calamities, bamboo will resurrect itself and give the sustenance to its owner.

1.02 The Eco Healer

A sixty-foot tree cut for market takes 60 years to replace. A sixty-foot bamboo cut for market takes 60 days to replace. Bamboo minimizes CO2 gases and generates up to 35% moreoxygen than equivalent stand of trees.



1 hectare of bamboo sequesters 62 tons of CO2/year whereas 1 hectare of youngforest sequesters 15 tons of CO2/year

1.03 Bamboo is Essential: Bamboo is one of those providential developments inNature which, like the horse, the cow, wheat and cotton, have been indirectly responsible forman's own evolution.
Bamboo is well placed to address four major global challenges

i. **Shelter Security**, through the provision of safe, secure, durable and affordablehousing and community buildings
ii. **Livelihood Security**, through generation of employment in planting primary and secondary processing, construction, craft and the manufacturing of the value-addedproducts
iii. **Ecological Security**, by conservation of forest through timber substitution, as an efficient carbon sink and as an alternative to non-biodegradable and high embodiedenergy materials such as plastics and metals.
iv. **Food Security**, through bamboo based agro-forestry systems, by maintaining the fertility of adjoining agricultural lands and as a direct food source i.e bamboo rice andbamboo shoots.

2.0. Sustainability

Sustainability indicates towards fulfilling the needs of current generations without compromising the needs of future generations, while ensuring a balance between economicgrowth, environmental care and social well-being.
For the first time in 1987, three pillars of sustainability were mentioned in the Brundtland Report - environment, society, and economy. Sustainable development built on top of these 3 pillars can be achieved when environmental protection, social equity, andeconomic profitability coexist without one area taking over any of the others.
According to this definition, the 3 pillars of sustainable development are seen as interacting with each other at the same level. While sustainable development resides at the intersection of the 3.

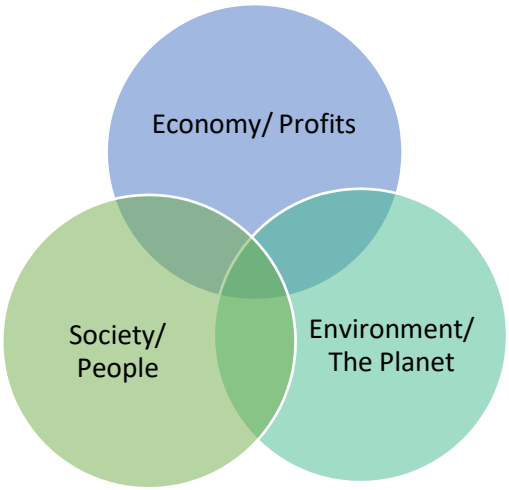


Figure 1

3 Pillars of Sustainable Development

2.01 Three Rs of Sustainability:
The 3R initiative aims to promote the "3Rs i.e., **Reduce, Reuse and Recycle"** globally soas to build a sound material cycle society through the effective use of resources and materials.
Reduce means to cut back on the amount of trash we generate.

Reuse means to find new ways to use things that otherwise would have been thrown out.

Recycle means to turn something old and useless (like old cups/ glasses) into something new and useful (like pen/ brush/cutlery holder etc)

In fact, Indian society is one of the oldest Societies to implement the concept of 3R, even much before it was established in 1976, when American Congress passed the Resource Conservation and Recovery Act to increase the efforts for recycling and conservation of waste, as waste became a bigger problem.

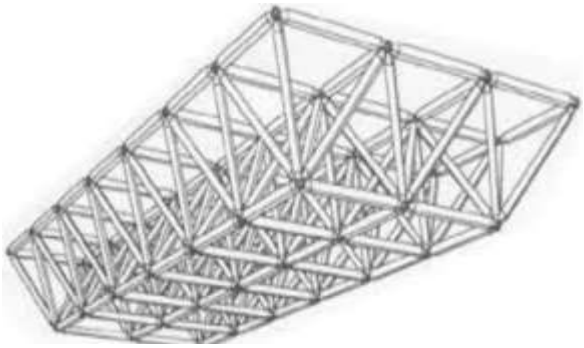
Figure 2

Indian house wives of ancient times were habitual of utilizing each and every waste coming out of their house for one or other purposes. For example, waste water will be used for gardening, vegetable peels and food waste can be used to feed local cows. They use to happily convert their beautiful but worn-out saris into bed linen. Later this bed linen will be converted into kitchen or basin napkins or door mats. These napkins will finally find their abode in dust bin after being used as car duster or table wipe for a pretty long time. So, each and every non-food item of a home had multiple uses. So, everyone was well implementing the concept of Reduce, Reuse and Recycle, since time immemorial.

3.0 Space Grid Structures:

3.01 Definition:

It's as a rigid, lightweight, truss-like, two-way spanning, single or double layer or triplelayer structure, constructed from interlocking struts in a geometric pattern, in flat or curved plane.

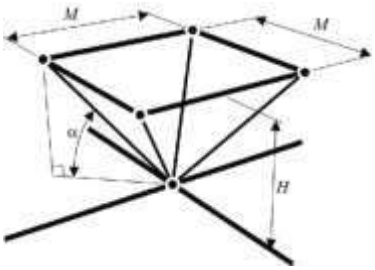


A typical pace grid structure

3.02 Structural Stability:

The reason of its immense strength and ability to span large and very large spans isbecause of

- **The inherent rigidity of the triangle**
- Flexing loads (bending moments) are transmitted as tension & compression loads alongthe length of each strut



Triangle, the basic unit of a space grid structure

3.03 Context

With the evolution of mankind, humans' shelters also evolved for various size of gatherings, for the purpose of prayer, sports and entertainment, education, commerce etc.

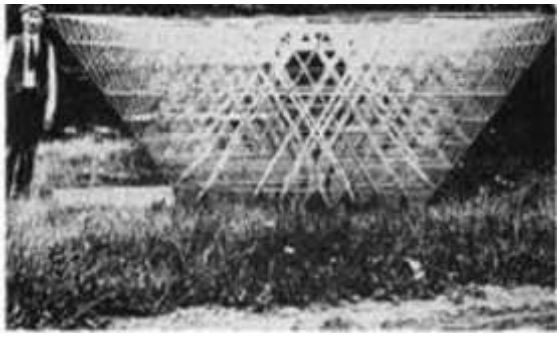
Likewise, the roof span of man-made structures evolved from small span to medium tolarge and very large span.

Until the middle of 18th century, stone, wood, brick, metal were used, to make arches, vaults and domes for a variety of spans. The domes of St Peter's Basilica in Rome (1588-93) and Santa Maria del Fiore, in Florence (1420-34) are both approximately 42 metres, at base, arethe largest


St. Peter's Basilica Dome, Rome

Industrial Revolution brought the wider production of iron, steel, high strength materials and also development of the mathematical techniques to describe and predict structural behaviorand understanding of strength of materials.

Equally, with the advent of railways and the industrialisation of commodity production came an increasing demand for longer span structures for bridges, stations, storage buildings and factories. New structural forms were worked out, initially with multiplicity of different truss configurations and eventually three-dimensional space grids. The earliest examples space grids or space frames were developed by Alexander Graham Bell, the inventor of telepho


Space frame by Alexander Graham Bell

First space grid systems commercially available were developed by Dr Ing. Max Mengeringhausen, in Germany, the MERO systems, in 1943.

Hypothesis:

The fibrous and mature cross-section of bamboo poles are strong enough to withstand thecompressive as well as tensile forces comparable to steel pipes, hence can replace tubular steel struts, in medium span space-grid structures

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Literature Study:

Bamboo space frame structures by Ingemar Saevfors, August 23, 2012
The space frame design is based on nodes connecting pole members of a standard length in a three dimensional and triangular pattern in a way that resembles four-sided pyramids1 between two horizontal grids. The free space between the lower and upper decks of the structureis often used for conduits, sprinklers and ventilation systems. The lower deck is ideal for supporting ceiling panels but often the structure is left uncovered and used as a strong architectural expression.
Normally the construction system is based on steel components industrially manufactured at millimeter precision. The challenge is always the connector design when eight members are meeting in one point. Unfortunately, these high-tech construction modules come very expensive.


Space Frame - State of the art: Aachen / Germany, 05.06.2003
An interesting feature however, is that only a relatively short length of the pole membersis needed and once an equal distance between the nodes is maintained the poles could take different shapes in between.
Bamboo is a perfect candidate for this concept with the tubular form of the culm and there are already applications in Latin America. Again, the challenge is to design a reliable pole connector to be produced at a reasonable cost. In addition, the bamboo culm end is vulnerable to cracking and great care must be taken when transferring loads to the connector nodes The construction is a tetrahedron and with it the minute-possible demonstration of a 3- dimensional structure. Linear grown bamboo is suitable for the reception of pressure and tensile forces ideally. Up to now, it neither was possible to realize complicated geometries, still it wasn'tpossible to take advantage of the high tensile strength of bamboo.



The tetrahedron made by the bamboo course in summer term 2003

Now we solved these problems. The bamboo rods prefabricated by us with their connections meet in a knot, at which they are simply screwed on. At laboratory examinations about the tensile strength, we could prove, that our connection can use the full tensile strength of bamboo tubes. The simplicity of the assembly and the capability of our connection technology offers completely new perspectives and up to now undreamt-of possibilities for building with bamboo.

Conclusion

Space grid structures consisting of struts and internodes, conventionally are being made up of steel, for both elements. By replacing steel struts with bamboo struts, it makes the structure, cost and time efficient with added goodness and elegance of bamboo, as bamboo has all mechanical properties to withstand the structural tests and internodes are specifically designedfor the purpose.
Concluding, it can be said that due to increase in calamities, the demand for temporary structures has gone up. In such circumstances Hybrid Bamboo Structures are efficient solution toprovide Sustainable Built Envelope.

References

1. Bamboo: an overview on its genetic diversity and characterization
2. Space Frame Structure; an analysis of its benefit
3. Exploring the three Rs of waste management — Reduce, Reuse, Recycle
4. Bamboo space frame structures by Ingemar Saevfors, August 23, 2012
5. Space Frame - State of the art: Aachen / Germany, 05.06.2003